

HYBRID APPLICATIONS (I/III)

- **Distributed Generation (<50MW)**
 - **Grid Support at Substations**
 - **Building Power**
 - **Residential (renewable and non-renewable)**
 - ✓ District
 - ✓ Individual
 - **Commercial**
 - **Power Park**
 - **Industrial**
 - **CHP**
 - **Service Industry**
 - **Carwashes**
 - **Restaurants**
 - **Laundromats**
 - **Hospitals**
 - **Institutional**
 - **Universities**
 - **Power Parks**
 - **Power Parks**
 - **Corporate Research Centers**
 - **Remote and Rural Applications**
 - **Waste Water Treatment Plant**

HYBRID APPLICATIONS (II/III)

- **Central Power Generation (>100 MW)**
 - **Baseload vs Peaking**
- **Mobile**
 - **Ship Power**
 - **Operational ship power**
 - **Ship hoteling while in port**
 - ✓ Grid augmentation
 - **Locomotive Power**
 - **Truck Hoteling**
 - **APU (approx 5 kW)**
 - ✓ Hybrid (cycle advantages) or just fuel cell (small system)?
 - ✓ Grid augmentation
 - ✓ Discussion
 - Is there really a market here for hybrids?
 - Noise pollution can play a role
 - **Truck stop could have hoteling support systems**
 - **RV Hoteling**
 - **Aircraft APU**

HYBRID APPLICATIONS (III/III)

- **Portable Generators**
- **Military**
 - **Radar Stations**
 - **Remote Command Centers**
 - **Portable Generators**
- **“Opportunity Fuel” Utilization**
 - **Agricultural Business**
 - **Wastewater**
 - **Landfill**
 - **Industrial byproduct fuels**
- **Co-Production of Chemical Byproducts**

TECHNICAL BARRIERS (I/III)

- **Grid Interaction, Interconnect**
 - **Inverters – Power Quality**
 - **Voltage converters**
 - **Fault Tolerance**
- **Control Technology Issues**
 - **Capacity and Demand Management**
 - **Load Following (electrical and thermal)**
 - **Dynamic Performance**
 - **Efficiency over Load Profile**
- **CHP / CCHP**
 - **Lack of absorption chilling technology**
 - **Strategies for integrating into an institutional complex (standardization)**
- **Load Following (Electrical and Thermal)**
- **Fuel Conditioning/Processing**
 - **Fuel Composition Variability**
 - **Fuel compression**
 - **Fuel flexibility at affordable cost**

TECHNICAL BARRIERS (II/III)

- **CHP / CCHP**
 - Lack of absorption chilling technology
 - Strategies for integrating into an institutional complex (standardization)
- **Load Following (Electrical and Thermal)**
- **Codes & Standards**
 - Mismatch between turbo machinery and pressure vessels
 - Interconnect
 - Fuel
 - ✓ Permitting (fire codes)
- **Reliability, Availability, Maintainability, Durability (RAMD)**
 - Availability of technically competent people
- **Fuel**
 - Sulfur content
 - Reforming (range of fuels)
 - ✓ fuel flexibility
- **Performance Engineering**
 - Startup Characteristics
 - Shut Down Characteristics
 - Multiple Skill Sets
 - IT: Monitoring/Dispatch; Operating Economics
 - Analyses: adequate software tools

TECHNICAL BARRIERS (III/III)

- **Education / Information dissemination**
 - **Public**
 - **City / county officials**
 - **Workforce development**
- **Intrinsic Cost**
 - **Materials**
 - **Manufacturing**
 - **Installation**
- **Immature Technology**
 - **Lack of Product Availability**
 - **Supplier Infrastructure**
 - **Thermally Driven Cooling**
 - **Grid Interconnect Hardware and Standards**
 - **Unproven Reliability**
 - **No Track Record**

MARKET BARRIERS (I/II)

- **High Costs**
 - Capital
 - Operational
 - ✓ Projected costs of energy (assumptions / scenarios)
 - ✓ Uncertainty of future costs (e.g. fuel)
- **Political / Regulatory Barriers**
 - Exit fees
 - Net metering
- **Permitting Challenges**
- **Uncertainty in Safety**
- **CHP**
 - Proving economic viability and reliability
 - Not Widely Accepted in U.S. Market
- **Lack of Track Record, Demonstration Choices**
 - Insurance / Risk Management
 - ✓ Lack for early projects / Ability to insure
- **Inadequate Codes & Standards**

MARKET BARRIERS (II/II)

- **Need for Workforce Development**
 - Servicing and Maintenance training
 - Installation
- **Long Lead Time to Commercialization**
- **Formidable Competition**
- **Entrenched Interests**
 - Utilities
 - Regulatory Agencies
 - Developers and Architects
- **Lack of Awareness/Education**
 - Public
 - City/County Officials

MARKET OPPORTUNITIES (I/II)

- **Forcing Functions (Drivers)**
 - **Efficiency**
 - **Low Emissions**
 - **Flexible use of power**
- **Potential Benefits of CHP**
- **Large niche markets**
 - **Grid congestion relief / grid support**
 - **Emission restrictions**
 - **Aging T&D**
 - **Environmental Justice**
 - **Re-powering (aging power plants)**
 - **Central Plant: V21/Future Gen**
 - **H2 Co-production**
 - **Rural / remote power**
- **Potential reliability**
- **Security / Energy Independence**
- **Fuel Flexibility**

MARKET OPPORTUNITIES (II/II)

- **Costs - Economic Arguments**
 - Hybrid could bring down cost of fuel cell
 - Availability of incentive programs
 - Operational Benefits
 - ✓ Projected costs of energy (assumptions / scenarios)
 - ✓ Hedge uncertainty of future costs (e.g. fuel)